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Conference Abstract

Traceability of Bees and their Products Using eDNA: Uncovering Biodiversity, Microbial Communities, and Bioeconomic Potential in Colombia

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Abstract

The demand for natural products that promote sustainable production chains is growing worldwide. Honey, while not a staple for food security due to its limited nutritional contribution, represents a valuable resource to foster dietary diversity, responsible consumption, and forest conservation. Its production depends directly on access to diverse flora with low pesticide exposure and requires minimal soil transformation or external inputs, making it a low-impact practice. Beekeeping also contributes to the maintenance of pollinator populations, which are key for biodiversity and sustainable agriculture. Consumer interest in the origin and authenticity of honey has grown in recent years, especially for *Apis mellifera* products (Escuredo and Seijo 2024, Mascarello et al. 2024).

Less known is the diversity and economic potential of stingless bees (Meliponini). Across tropical and neotropical regions, nearly 500 species have been described (Grüter 2020), many of which produce honey and act as key pollinators. In Colombia, about 34 species are reportedly used in meliponiculture (Nates-Parra and Rosso-Londoño 2013). This

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practice is expanding in rural areas, where it complements agriculture and is compatible with family-centered management. Traditional knowledge attributes medicinal properties to stingless bee products (Sgariglia et al. 2010, Rosales 2012). Although clinical validation remains limited, biochemical studies of their honeys have identified distinctive compositions rich in phenolic compounds and other bioactive molecules, providing preliminary evidence of antioxidant and anti-inflammatory properties that warrant further research (Gomes et al. 2022).

These properties are linked to microbial communities naturally present in stingless bee honeys. Fermentative yeasts and lactic acid bacteria shape these products, creating unique ecological niches with potential probiotic and bioactive value (da Silva et al. 2024). Microbial assessment is also essential to detect possible pathogens, as not all stingless bee species are recommended for meliponiculture: *Trigona* species, for example, may incorporate feces or dead animal tissue into nests, raising sanitary concerns (Gómez et al. 2023)

Developing markets for stingless bee products requires robust methodologies for authentication and safety. We propose environmental DNA (eDNA) as a tool to address three dimensions of traceability and diversity assessment:

1. **Entomological origin of honey.** Despite vast bee diversity, taxonomic expertise has declined, limiting our ability to monitor wild bees. DNA-based approaches, particularly metabarcoding, enable verification of the bee taxa involved in honey production—critical in regions with limited expertise. Challenges include primer selection for non-*Apis* bees, expanding reference databases, and training in molecular methods. Incorporating eDNA and metabarcoding into product traceability could democratize biodiversity monitoring and inform public policy.

2. **Botanical foraging spectrum.** DNA from bee pollen and honey reveals floral visitation patterns, offering a proxy for ecosystem health. Progress is constrained by incomplete plant reference libraries. Diversity indices—borrowed from microbiome studies—can help characterize floral communities, though interpretation must account for variable foraging behavior across bee species.

3. **Microbial diversity and bioprospecting.** Stingless bee honeys act as natural "filters," concentrating microbial communities with industrial, probiotic, or antibiotic potential. Although generally safe, rigorous biosafety evaluation is needed to balance opportunities with risks. Reliable isolation and cultivation methods will be key to characterize diversity, establish reference libraries, and develop pipelines for future bioprospecting.

Our pilot project, in the Magdalena Medio region of Colombia, applies eDNA analyses to bees, honey, pollen, and associated microorganisms. The study focuses on three genera of stingless bees maintained in boxes derived from colonies collected *in situ* in the El Silencio nature reserve of Fundación Biodiversa Colombia, ensuring foraging in a pesticide-free environment with high floral diversity. As one of the first efforts to apply

DNA-based tools to stingless bee biodiversity surveys and product authentication, this initiative highlights the need for stronger collaboration, standardized data frameworks, and investment to unlock the potential of eDNA for conservation and bioeconomic development.

Keywords

tribe Meliponini, botanical and entomological origins, probiotic potential

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Conflicts of interest

The authors have declared that no competing interests exist.

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